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Olon et al.

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[54] **FAILURE COMPENSATION CIRCUIT WITH THERMAL COMPENSATION**

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[51] **Int. Cl.**[4] **H05B 41/30**

[52] **U.S. Cl.** .... **307/11**; 307/10 LS; 340/642; 340/81 R; 315/135; 315/130

[58] **Field of Search** .... 307/9, 10 R, 10 BP, 307/10 LS, 11; 340/52 R, 52 D, 52 F, 88, 641, 642, 521; 324/83 D; 315/47, 50, 55, 57, 58, 64, 71, 74, 75, 76, 77, 80, 82, 83, 112, 113, 117, 120, 126, 127, 129, 123, 135, 88, 89, 130; 323/905

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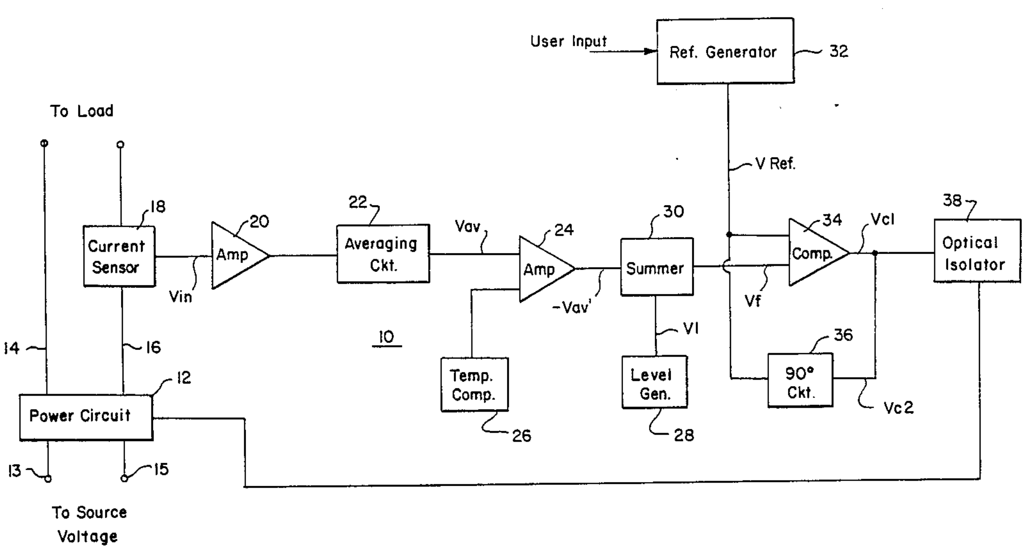
[57] **ABSTRACT**

A failure compensation circuit automatically reduces the output voltage of a power supply when a portion of a load drops out. The compensation circuit includes a circuit for generating a control signal representative of the desired voltage across the load. A power supply supplies voltage to the load in response to the control signal. An input signal representative of the current delivered to the load is produced which decreases whenever a portion of the load drops out. The circuit for generating the control signal is responsive to the input signal for adjusting the control signal such that when the current delivered to the load decreases, the voltage delivered to the load is automatically reduced.

16 Claims, 4 Drawing Sheets



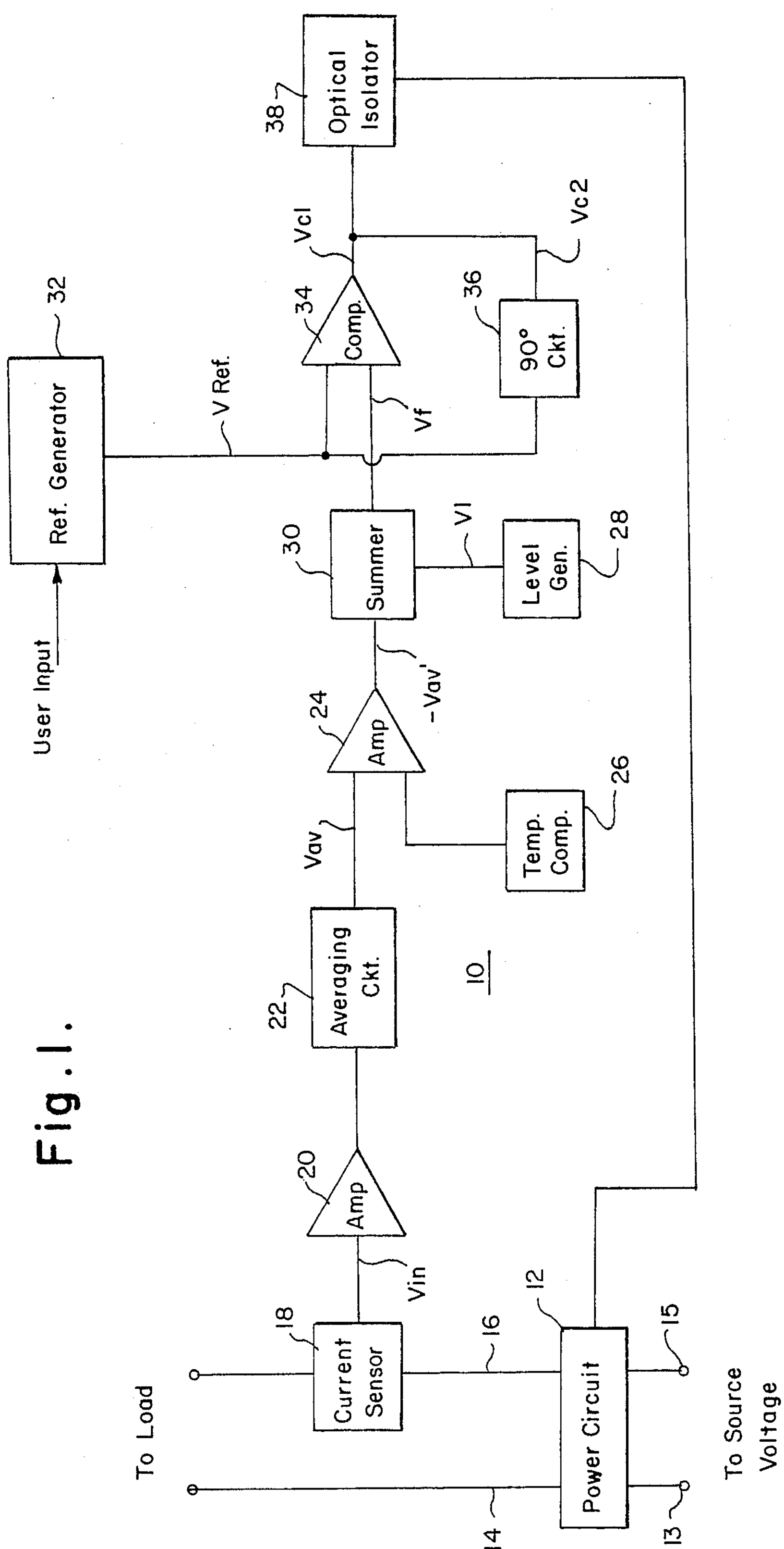

Optical Isolator
38
Vcl
Vc2
32
Ref. Generator
V Ref.
User Input
34
Comp.
36
90° Ckt.
Vf
30
Summer
Vl
Level Gen.
28
24
Amp
-Vav'
26
Temp. Comp.
Vav
22
Averaging Ckt.
10
20
Amp
Vin
18
Current Sensor
16
12
Power Circuit
15
13
14
To Load
To Source Voltage

Fig. 1.

Fig. 2.

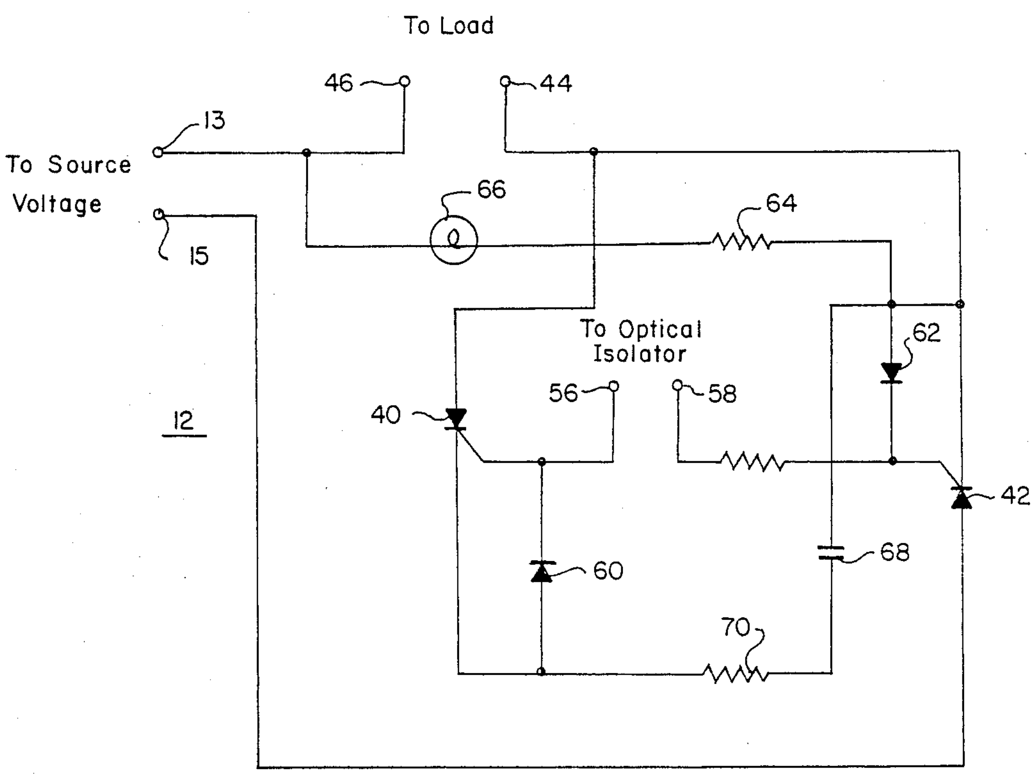

To Load
46
44
13
To Source Voltage
15
66
64
12
To Optical Isolator
62
56
58
40
42
60
68
70

Fig.3A.

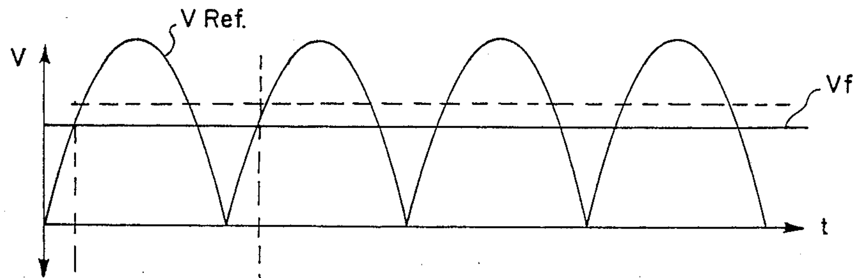


Fig.3B.

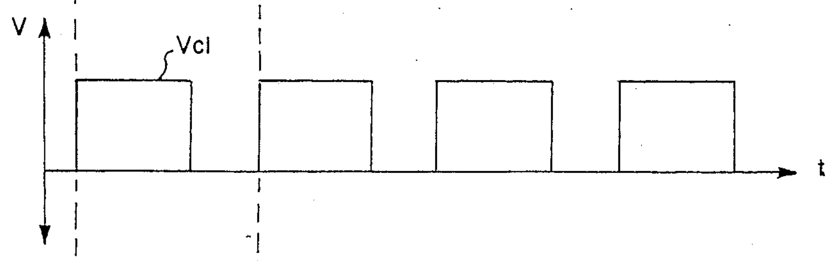


Fig.3C.

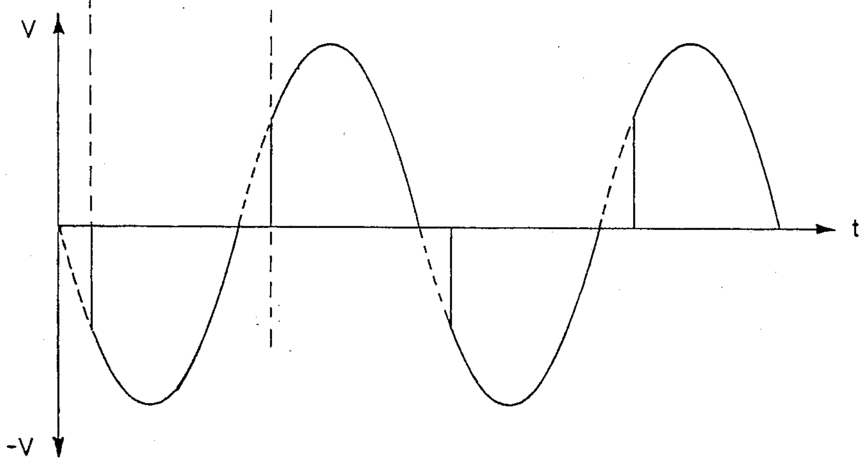
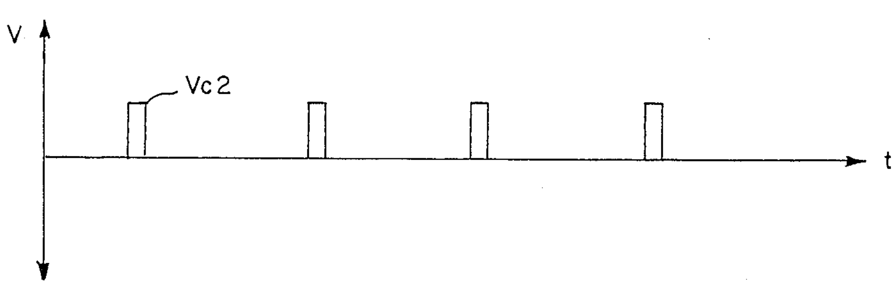


Fig.3D.



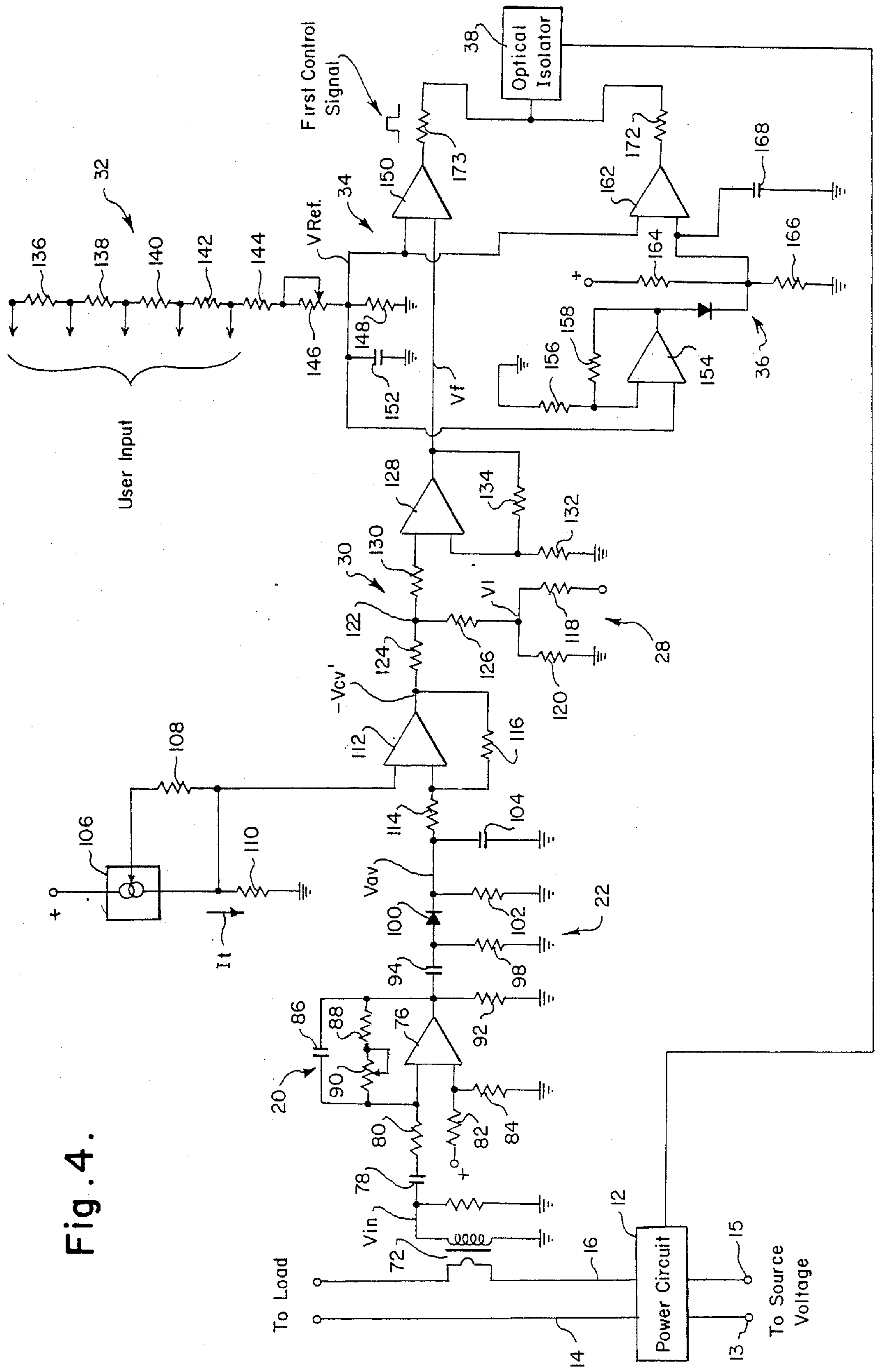

Optical Isolator
First Control Signal
VRef.
Vf
User Input
-Vcv'
VI
Vav
It
Vin
To Load
Power Circuit
To Source Voltage

Fig. 4.

FAILURE COMPENSATION CIRCUIT WITH THERMAL COMPENSATION

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention is directed to controllers and more particularly to compensation circuits which react to load changes.

There are a wide variety of controllers used to supply power to various types of loads. Controllers used to supply power to multiple lamps may include constant current or constant voltage types of controllers. Problems are encountered, however, when one lamp of a parallel connected group of lamps fails. The decrease in voltage drop across the line when a lamp fails increases the voltage across the remaining lamps. A constant voltage source, because it is incapable of recognizing that one of the lamps has failed, continues to supply the same voltage to the line plus the lamp load, resulting in a decreased voltage drop across the line resistance and an increased voltage across the lamp load. This may cause a premature failure of the remaining lamps.

A constant current source suffers from an even greater problem. When a lamp of a parallel connected group of lamps fails, the current drawn by the lamp group decreases. The constant current source, sensing a drop in current, increases its output voltage to maintain a constant current output. In that situation, the remaining lamps must dissipate the additional power resulting from the increase in the voltage output from the controller.

There is a need for a lamp controller capable of recognizing when one lamp of a parallel connected group of lamps fails. In response to that lamp's failure, the voltage output from the controller should be reduced so that the remaining lamps do not fail prematurely.

Another problem which prior art controllers suffer from is thermal drift. It is well known that the output of various electrical components drifts as the temperature of the component changes. The typical prior art solution is to provide an additional circuit element such as a thermistor which has a similar thermal drift but in the opposite direction. The problem with supplying thermistors is that the thermistor must be carefully matched to the thermal drift of the element for which compensation is required. Where there is a line of related products, it is often necessary to have a special thermistor for each product. This results in increased spare parts inventory as well as increased maintenance cost.

SUMMARY OF THE PRESENT INVENTION

The present invention is directed to a failure compensation circuit for automatically reducing the output voltage of a power supply when a portion of a load drops out. The compensation circuit comprises a circuit for generating a control signal representative of the desired voltage across the load. A power supply supplies voltage to the load in response to the control signal. An input signal is produced which is representative of the current delivered to the load. That current decreases in response to a portion of the load dropping out. The means for generating the control signal is responsive to the input signal for adjusting the control signal such that when the current decreases, the voltage delivered to the load is automatically reduced.

The present invention, when used with a group of parallel connected lamps, is capable of sensing the failure of one of the lamps. In response to that lamp's failure, the voltage is reduced such that the remaining lamps are not subjected to an overvoltage condition. This prevents premature failure of the remaining lamps.

The invention also contemplates the use of a constant current source having a known thermal drift. The amount of thermal drift is related to the value of the current produced by the constant current source. Thus, the constant current source can be manipulated so that the thermal drift of the constant current source matches the thermal drift of the elements in the circuit which require compensation. Because the amount of thermal drift for which compensation can be provided is adjustable by simply adjusting the amount of current produced by the constant current source, a single type of constant current source can be used to provide thermal compensation in a wide variety of products. This allows a single component to be used in multiple applications which reduces spare parts inventory and maintenance costs. These and other advantages and benefits of the present invention will become apparent from the following description of a preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the present invention may be clearly understood and readily practiced, a preferred embodiment will now be described, by way of example only, with reference to the accompanying figures wherein:

FIG. **1** is a block diagram illustrating a failure compensation circuit constructed according to the teachings of the present invention;

FIG. **2**, is an electrical schematic illustrating the details of the power circuit shown in FIG. **1**;

FIGS. **3A–3D** illustrate various waveforms useful for understanding the operation of the present invention; and

FIG. **4** is an electrical schematic illustrating the details of a failure compensation circuit constructed according to the teachings of the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

I. Structural System Overview

FIG. **1** illustrates a failure compensation circuit **10** constructed according to the teachings of the present invention. The failure compensation circuit will be described in the context of a controller for a parallel connected group of lamps. However, the reader should appreciate that the teachings of the present invention are equally applicable to other types of power sensitive loads.

In FIG. **1**, a power circuit **12**, connectable at input terminals **13** and **15** to a source voltage (not shown), delivers power to the load (not shown) through a pair of conductors **14** and **16**. A current sensor **18** is responsive to the current flowing through conductor **16**.

The current sensor **18** produces an input signal V_{in} which is amplified by an amplifier **20** and input to an averaging circuit **22**. The averaging circuit **22** produces an average value signal V_{av} which is the average value of the input signal V_{in}.

The average value signal V_{av} is input to an amplifier **24** which inverts the average value signal V_{av}. It is known that the average value signal V_{av} drifts due to temperature variations of the various components, particularly the current sensor **18**. For that reason, a temperature compensation circuit **26** is provided which produces a signal that compensates for the drift in the average value signal V_{av}. The signal produced by the temperature compensation circuit **26** is input to the amplifier **24** such that the amplifier **24** produces an inverted, temperature compensated, average value signal $-V_{av}'$.

A level generator **28** produces a level signal V_1 which is combined with the temperature compensated average value signal $-V_{av}'$ in a summer **30** to produce a firing level signal V_f.

A reference generator **32** produces a reference signal V_{ref} which is representative of the desired voltage across the load. The reference generator **32** is responsive to user input such that the user can adjust the desired voltage across the load.

The firing level signal V_f and the reference signal V_{ref} are compared in a comparator **34**. In response to that comparison, the comparator **34**. In response to that comparison, the comparator **34** produces a first control signal V_{cl} which is representative of the desired voltage across the load. The manner in which the first control signal V_{cl} is produced, and the use of the first control signal, are discussed in more detail hereinbelow in the section entitled "FUNCTIONAL SYSTEM OVERVIEW".

It is possible under certain circumstances that the comparison by comparator **34** of the reference signal V_{ref} and the firing level signal V_f will not produce the first control signal V_{cl}. For that reason, a 90° circuit **36** is provided. The 90° circuit is responsive to the reference signal V_{ref} and is constructed to guarantee the production of a second control signal V_{c2}. The second control signal insures that a certain minimal amount of power will be supplied to the load.

The power circuit **12** is responsive to both the first and second control signals through an optical isolator **38**. The second control signal is always generated but is only used by the power circuit in the event that the first control signal is not generated.

II. Functional System Overview

To understand how the failure compensation circuit **10** of the present invention functions, it is helpful to have some understanding of the construction and operation of the power circuit **12**. FIG. **2** illustrates an electrical schematic of the power circuit **12** shown in FIG. **1**. The power circuit **12** is a conventional circuit for phase controlling the firing of two back to back connected silicon controlled rectifiers **40** and **42**.

The anode of the SCR **40** and the cathode of the SCR **42** are connected to an output terminal **44**. The cathode of the SCR **40** and the anode of the SCR **42** are connected to the input terminal **15** which is connectable to a source voltage (not shown). The second input terminal **13** is connected to a second output terminal **46**. The output terminals **44** and **46** are connectable to the conductors **14** and **16** for delivering power to the load.

A gate terminal of the SCR **40** is connected to a control input terminal **56** while a gate terminal of the SCR **42** is connected to a control input terminal **58**. The control input terminals **56** and **58** are responsive, through the optical isolator **38**, to the first and second control signals.

A diode **60** is connected between the control input terminal **56** and the input terminal **15**. The gate terminal of the SCR **42** is connected to the cathode of the SCR **42** through a diode **62**. The junction between the anode of the diode **62** and the cathode of the SCR **42** is connected to the input terminal **13** through the series connection of a resistor **64** and an indicator lamp **66**. That junction is also connected to the input terminal **15** through the series combination of a capacitor **68** and a resistor **70**.

The SCRs **40** and **42** operate in a conventional manner by conducting source voltage from terminals **13** and **15** to output terminals **44** and **46** depending upon the control signal input at their gate terminals. The operation of the power circuit **12** and the production of the first control signal V_{cl} by comparator **34** may be more easily understood by reference to FIGS. 3A, 3B, and 3C.

In FIG. 3A the reference signal V_{ref} is illustrated. This signal V_{ref} is in phase with the supply voltage available at input terminals **13** and **15**. The supply voltage is shown in dotted lines in FIG. 3C. The reference signal V_{ref} and the supply voltage available at terminals **13** and **15** may be produced, for example, by a multiple tap transformer.

The reference signal V_{ref} is compared by comparator **34** to the firing level signal V_f. The firing level signal V_f is itself comprised of two components, the level signal V_1 and the temperature compensated average signal $-V_{av}'$. Whenever the instantaneous value of the reference signal V_{ref} equals the value of the firing level signal V_f, the first control signal V_{cl} is produced as shown in FIG. 3B. The first control signal causes the SCR **40** or **42**, whichever is properly biased, to become conductive and continue conducting power until the voltage waveform passes through zero as shown in FIG. 3C. Thus, the waveform shown in FIG. 3C is the voltage delivered to the load.

It will be apparent to the reader that because the reference signal V_{ref} can be manipulated by the user, the voltage ultimately delivered to the load can be adjusted by the user. By increasing the magnitude of the reference signal V_{ref}, the reference signal more quickly equals the firing level signal V_f such that more power is delivered to the load. By decreasing the value of the reference signal V_{ref}, it takes longer for the value of the reference signal V_{ref} to equal the value of the firing level signal V_f such that less power is delivered to the load. Those skilled in the art will recognize that this is a typical method of controlling the operation of silicone controlled rectifiers. By advancing or retarding the SCR conduction angle, load RMS voltage is controlled.

As previously stated, the voltage delivered to the load can be varied by the user by changing the magnitude of the reference signal V_{ref}. However, it should be apparent that the voltage delivered to the load can also be changed by changing the value of the firing level signal V_f. The firing level signal is comprised of two components, the first component being the level signal V_1 generated by the level generator **28**. That component is fixed and does not change throughout the operation of the failure compensation circuit **10**. The other component of the firing level signal V_f is the temperature compensated average signal $-V_{av}'$. During normal operation, that signal changes only when the user changes the magnitude of the reference signal V_{ref}. When the user increases the value of the reference signal V_{ref}, that causes an increase in the current delivered to the load. The increased current increases the value of the input signal V_{in}. Because the reference generator **32** is calibrated to compensate for the new firing level signal V_f, increased power is delivered to the load. The converse occurs whenever the user decreases the value of the reference signal V_{ref} in order to decrease the power delivered to the load.

The major function of the temperature compensated average signal $-V_{av}'$ is to automatically reduce the voltage output by the power circuit **12** whenever a load drops out such as when a lamp failure occurs. Whenever there is a lamp failure, the current delivered to the load decreases. That decrease is sensed by the current sensor such that the value of the average value signal V_{av} is reduced. This reduced signal is inverted, temperature compensated, and combined in summer **30** with the fixed level signal V_1 such that the firing level signal V_f increases. That increase is shown in FIG. **3A** by the dotted line. Of course, with the firing level signal V_f increased, it takes longer for the instantaneous value of the reference signal V_{ref} to equal the value of the firing level signal V_f such that less voltage is delivered to the load. In this manner, the failure of a lamp, or dropping out of a load, causes the fire level signal V_f to increase such that less voltage is automatically delivered to the load. That reduced voltage prevents the remaining lamps from failing prematurely.

III. System Details

A. Current Sensor 18, Amplifier 20, Averaging Circuit 22

The current sensor **18** illustrated in FIG. **1** may be comprised of a transformer **72** having a single turn primary winding as shown in FIG. **4**. The transformer **72** is loaded with a resistor **74** connected to ground. The transformer **72** provides isolation and a means of sensing current without adding unwanted resistance.

The input signal Vin, produced by the transformer **72**, is input to an inverting input terminal of an operational amplifier **76** through a coupling capacitor **78** and a resistor **80**. The operational amplifier **76** has a noninverting input terminal connected to a positive voltage source through a resistor **82** and connected to ground through a resistor **84**. An output terminal of the operational amplifier **76** is connected to the inverting input terminal thereof through a capacitor **86** connected in parallel with the series combination of a resistor **88** and a variable resistor **90**. The output terminal of the operational amplifier **76** is also connected to ground through a resistor **92**.

The amplified input signal V_{in} is input to an input node **96** of the averaging circuit **22** through a coupling capacitor **94**. The averaging circuit **22** is comprised of a resistor **98** connected between the input node **96** and ground, the series combination of a diode **100** and a resistor **102** connected between the input node **96** and ground, and a capacitor **104** connected between the junction of the diode **100** and resistor **102**, and ground. The average signal V_{av} is available across capacitor **104**.

B. Temperature Compensator 26 And Amplifier 24

It is known that the average signal V_{av} available at the output of the averaging circuit **22** varies with temperature such that the following relationship exists:

$$V_{av}=V_{dc}+(\Delta V_{av}/\Delta T) \quad (1)$$

where V_{dc} is the DC component of the average signal V_{av} and $\Delta V_{av}/\Delta T$ represents the change in the average signal with respect to time, i.e. the thermal drift.

To compensate for that thermal drift, a constant current source **106** is provided. The constant current source **106** has an input terminal connected to a positive voltage source and an output terminal connected to a control terminal through a resistor **108**. The output terminal is also connected to ground through a resistor **110**. The constant current source may be of a known type such as a LM134, LM234, or LM334.

The total current I_t produced by the constant current source **106** is determined by the value of the resistor **108**. The current I_t produced by the constant current source **106** may be expressed as follows:

$$T_t=I_{set}+(\Delta I_{set}/\Delta T) \quad (2)$$

where I_{set} is the current produced by the constant current source **106** and $(\Delta I_{set}/\Delta T)$ represents the change in the current over time, i.e. the thermal drift. For a known current source, the thermal drift is known. For example:

$$\Delta I_{set}/\Delta T=0.3\%\ I_{set}/^{\circ}C. \quad (3)$$

The thermal drift of the average signal V_{av} can be measured. It is desirable to manipulate the current produced by the constant current source **106** such that the component of thermal drift of the current I_{set} is equal to the thermal drift of the average signal V_{av}. Mathematically,

$$(\Delta I_{set}/\Delta T)(R_{110})=\Delta V_{av}/\Delta T \quad (4)$$

Assuming $\Delta V_{av}/\Delta T$ is known from measurements to be $0.01\,V/^{\circ}C.$, *and substituting from equation (*3):

$$(0.003\ I_{set}/^{\circ}C.)(R_{110})=0.01\,V/^{\circ}C. \quad (5)$$

Assuming R_{110} equals 10 kΩ, then

$$I_{set}=0.333\ ma \quad (6)$$

From equation 6, the value of I_{set} is determined. Knowing the value of the current I_{set}, the value for the resistor **108** can be chosen from the manufacturer's specifications to provide the desired current. In this manner, temperature compensation for a wide range of products can be provided by using standard components. This reduces parts inventory and simplifies field repairs.

The voltage produced across resistor **110** is input to a noninverting input terminal of an operational amplifier **112**. The average signal V_{av} is input to an inverting input terminal of the operational amplifier **112** through a resistor **114**. The inverting input terminal of the operational amplifier **112** is connected to an output terminal thereof through a resistor **116**. The operational amplifier **116** inverts the average signal V_{av} and removes the thermal component therefrom thus producing the temperature compensated average signal $-V_{av}'$.

C. Level Generator 28 and Summer 30

The level generator **28** may be comprised of a pair of series connected resistors **118** and **120** connected between a positive source of voltage and ground. The resistors **118** and **120** are a voltage divider such that the level signal V_1 is available at the junction between the two resistors.

A summing node **122** is provided which receives the temperature compensated average signal $-V_{av}'$ through a resistor **124** and the level signal V_1 through a resistor **126**. The combination of the two signals $-V_{av}'$ and V_1 produces the firing level signal V_f. The firing level signal V_f is input to a noninverting input terminal of an operational amplifier **128** through a resistor **130**. An inverting input terminal of the operational amplifier **128** is connected to ground through a resistor **132** and to an output terminal thereof through a resistor **134**. The operational amplifier **128** may be used to buffer and amplify the firing level signal V_f as needed. Thus, the firing level signal V_f is available at the output terminal of the operational amplifier **128**.

D. Reference Generator **32** Comparator **34** And 90° Circuit **36**

The reference generator **32** is comprised of a string of series connected resistors. Resistors **136**, **138**, **140**, **142**, **144**, adjustable resistor **146**, and resistor **148** are connected in series between a positive source of voltage (not shown) and ground. The resistors are responsive to user input such that they may be switched into or out of the string of resistors. Clearly, by removing resistors from the resistive string the reference signal V_{ref} is increased and by adding resistors to the resistive string the reference signal V_{ref} is decreased.

The junction between the resistors **146** and **148** is connected to a noninverting input terminal of an operational amplifier **150**. An inverting input terminal of the operational amplifier **150** receives the firing level signal V_f. The first control signal V_{c1} is available at an output terminal of the operational amplifier **150**. The operational amplifier **150** performs the function of the comparator **34** shown in FIG. 1. The first control signal V_{c1} available at the output terminal of the operational amplifier **150** assumes a high state whenever the instantaneous value of the reference signal V_{ref} equals the value of the firing level signal V_f as described above in conjunction with the power circuit **12**.

A capacitor **152** is connected across the junction between resistors **146** and **148** and ground. The junction between the resistors **146** and **148** is also connected to a noninverting input terminal of an operational amplifier **154**. An inverting input terminal of the operational amplifier **154** is connected to ground through a resistor **156** and to an output terminal thereof through a resistor **158**. The output terminal of the operational amplifier **154** is connected through a diode **160** to an inverting input terminal of an operational amplifier **162**. The inverting input terminal of the operational amplifier is connected to a positive voltage source through a resistor **164**, to ground through a resistor **166**, and to ground through a capacitor **168**.

In operation, the capacitor **168** charges to the peak value of the reference signal V_{ref} minus 0.2V ($V_{ref}' = V_{ref} - 0.2V$). That value V_{ref}' is used as a second firing level signal by comparing it to the instantaneous value of the reference signal V_{ref} which is input to a noninverting input terminal of the operational amplifier **162**. As seen in FIG. 3D, the second control signal V_{c2}, which is available at the output terminal of the operational amplifier **162**, assumes a high state whenever the instantaneous value of the reference signal V_{ref} equals the value of the signal V_{ref}'.

Under normal operating conditions, by the time the second control signal V_{c2} assumes a high state, the first control signal V_{c1} will have assumed a high state such that one of the SCRs **40** or **42** will be conductive. Under those circumstances, the second control signal is not needed. However, under extraordinary circumstances it is possible that the instantaneous value of the reference signal V_{ref} never equals the value of the firing level signal V_f such that the first control signal is not produced. When that occurs, the power circuit **12** then becomes responsive to the second control signal. The second control signal assures that once each cycle, each SCR **40** and **42** will fire. That results in a conduction of a minimum amount of power to the load and prevents the power circuit **12** from becoming unstable and operating in a half-wave mode. Because the second control signal is always produced whenever the reference signal V_{ref} has a phase angle of substantially 90 degrees, the components producing the second control signal are referred to as a 90° circuit.

The second control signal is input to the optical isolator **38** through a resistor **172** and OR'ed to the first control signal, which is input to the optical isolator through a resistor **173**. The optical isolator **38** may be any commercially available known type of isolator.

IV. Conclusion

The present invention is directed to a controller used for supplying voltage to voltage sensitive loads. Unlike conventional controllers, whenever a load drops out, the voltage supplied to the remaining loads is decreased rather than increased to protect the remaining loads from having to dissipate too much power. The present invention achieves that result by providing circuitry which is responsive to the average value of a signal representative of the current delivered to the load. The present invention also provides temperature compensation for various components within the failure compensation circuit. This temperature compensation is provided by using the known thermal drift of the components of the failure compensation circuit. Thus, a single off the shelf component can be used to replace a wide variety of fixed thermistors.

While the present invention has been described in connection with an exemplary embodiment thereof, it will be understood that many modifications and variations will be readily apparent to those of ordinary skill in the art. This disclosure and the following claims are intended to cover all such modifications and variations.

What we claim is:

1. A failure compensation circuit for automatically reducing the output voltage of a power supply when one or more lamps fail, said compensation circuit comprising:

- means for generating a control signal representative of the voltage to be supplied to the lamps;
- power supply means for supplying voltage to the lamps in response to said control signal; and
- means for producing an input signal representative of the current delivered to the lamps, said current decreasing in response to each lamp failure;
- said means for generating a control signal being responsive to said input signal for adjusting said control signal such that when said current decreases said voltage supplied to the lamps is automatically reduced.

2. A failure compensation circuit for automatically reducing the output voltage of a power supply when one or more lamps fail, said compensation circuit comprising:

- power supply means for supplying voltage to the lamps in response to a control signal;
- means for producing an input signal representative of the current delivered to the lamps, said current decreasing in response to each lamp failure.
- means for generating a reference signal representative of the desired lamp intensity;

means for combining said input signal and said level signal

means for combining said input signal and said level signal to produce a firing level signal;

means for comparing said firing level signal to said reference signal for producing said control signal such that when said current decreases said firing level signal increases thereby automatically reducing the voltage delivered to the lamps.

3. The failure compensation circuit of claim **2** additionally comprising means for generating a second control signal representative of a minimum voltage across the lamps, said power supply means being responsive to one of said first and second control signals.

4. The failure compensation circuit of claim **3** wherein said means for generating a second control signal includes means responsive to said reference signal for producing a second firing level signal and including means for comparing said second firing level signal to said reference signal for producing said second control signal in response to said comparison.

5. The failure compensation circuit of claim **1** wherein the current delivered to the lamps is alternating current, and wherein said means for producing an input signal includes a current transformer responsive to the current delivered to the lamps and an averaging circuit responsive to said current transformer.

6. The failure compensation circuit of claim **5** wherein said averaging circuit produces an average value over approximately five cycles.

7. The failure compensation circuit of claim **1** wherein said means for producing an input signal has a known thermal drift, said failure compensation circuit additionally comprising a constant current source having a known thermal drift, and an amplifier responsive to said input signal and said constant current source such that said thermal drift of said constant current source compensates for said thermal drift of said means for producing an input signal.

8. A failure compensation circuit for automatically reducing the output voltage of a power supply when a portion of a load drops out, said compensation circuit comprising:

means for generating an AC reference signal representative of the desired AC voltage across the load;

means for generating a first DC firing level signal;

means for comparing said first firing level signal to the instantaneous value of said reference signal for producing a first control signal in response to said comparison;

power supply means for supplying AC voltage to the load in response to said first control signal;

means for producing a DC input signal representative of the current delivered to the load, said current decreasing in response to a portion of the load dropping out; and

means for adjusting said first firing level signal in response to said input signal such that when said load current decreases the voltage delivered by said power supply means is automatically reduced.

9. A failure compensation circuit for automatically reducing the output voltage of a power supply when a portion of a load drops out, said compensation circuit comprising:

means for generating an AC reference signal representative of the desired AC voltage across the load;

means for generating a first DC firing level signal;

means for comparing said first firing level signal to the instantaneous value of said reference signal for producing a first control signal in response to said comparison;

means for generating a second control signal representative of a minimum voltage across the load;

power supply means for supplying AC voltage to the load in response to one of said first and second control signals;

means for producing a DC input signal representative of the current delivered to the load, said current decreasing in response to a portion of the load dropping out; and

means for adjusting said first firing level signal in response to said input signal such that when said load current decreases the voltage delivered by said power supply means is automatically reduced.

10. The failure compensation circuit of claim **9** wherein said means for generating a second control signal includes means responsive to said rectified AC reference signal for producing a second DC firing level signal and including means for comparing said second firing level signal to the instantaneous value of said reference signal for producing said second control signal in response to said comparison.

11. The failure compensation circuit of claim **10** wherein said second control signal is produced substantially when said rectified AC reference signal reaches its peak value.

12. The failure compensation circuit of claim **8** wherein said means for producing a DC input signal includes a current transformer responsive to the current delivered to the load and an averaging circuit responsive to said current transformer.

13. The failure compensation circuit of claim **8** wherein said means for producing a DC input signal has a known thermal drift, said failure compensation circuit additionally comprising a constant current source having a known thermal drift, and an amplifier responsive to said input signal and said constant current source such that said thermal drift of said constant current source compensates for said thermal drift of said means for producing an input signal.

14. The failure compensation circuit of claim **8** wherein said means for adjusting includes means for increasing the value of said firing level signal in response to the decrease in said input signal such that the voltage delivered by said power supply means is automatically reduced.

15. The failure compensation circuit of claim **8** wherein said power supply means includes a pair of silicon controlled rectifiers connected for supplying AC voltage to the load in response to said first control signal.

16. The failure compensation circuit of claim **15** additionally comprising an optical isolator between said means for producing a first control signal and said pair of silicon controlled rectifiers.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,792,701

DATED : December 20, 1988

INVENTOR(S) : Thomas E. Olon et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Col. 8, line 31, after "of" insert --a constant current source to cancel out the known thermal drift of--.

Col. 8, line 66, after "failure" cancel "." and substitute therefor --,--.

Col. 9, line 1, cancel "means for combining said input signal and said level signal" and substitute therefor --means for generating a level signal;--.

Col. 9, line 32, cancel "1" and substitute therefor --2--.

Col. 10, line 25, cancel "rectified".

Col. 10, line 33, cancel "rectified".

Col. 10, line 35, cancel "8" and substitute therefor --9--.

Col. 10, line 40, cancel "8" and substitute therefor --9--.

Col. 10, line 49, cancel "8" and substitute therefor --9--.

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 4,792,701

DATED : December 20, 1988

INVENTOR(S) : Thomas E. Olon et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Col. 10, line 55, cancel "8" and substitute therefor --9--.

Signed and Sealed this

Fourth Day of September, 1990

Attest:

HARRY F. MANBECK, JR.

Attesting Officer *Commissioner of Patents and Trademarks*